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ABSTRACT

This document is one of five learning packets on alternative energy developed as part of a descriptive curriculum research project in Arkansas (see note). The overall objectives of the learning packets are to improve the level of instruction in the alternative energies by vocational exploration teachers, and to facilitate the integration of new content on energy into existing vocational programs. Each learning packet contains unit objectives, information, transparency masters, lecture outline, suggested activities, student assignment sheets, tests, and answers to the tests. This unit on wind power covers the following topics: introduction to wind power; historical development of wind power in the United States; initial considerations and costs of wind power; the basics of a wind-powered energy conversion system; and the Energy Research and Development Administration wind energy program. A glossary is also provided. (KC)

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WIND POWER
INSTRUCTIONAL MATERIALS

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USE OF THIS PUBLICATION

The overall objective of this publication is to improve the level of instruction in the alternative energies by vocational exploration teachers.

The development of alternative sources of energy and the increasing demand for energy conservation require that vocational educators develop new curriculum and improve existing delivery systems. All vocational education instructors must begin to acquire a minimum background in alternative energy sources and must be prepared to respond in a positive way to the energy education needs within their areas of specialization. It is anticipated that the use of this prepared learning package will facilitate the integration of new content on energy into existing vocational programs.

INSTRUCTIONAL UNIT

This packet contains objectives, information, transparency masters, lecture outline, suggested activities, student assignment sheets, tests and answers to the tests. These materials have been printed on colored paper to code their use. The following key will help easily identify each use by color:

White - teacher instructional materials

Green - information materials, teacher and student use

Yellow - student assignment materials

Golden - tests, teacher controlled

Pink - answers to tests and assignments, teacher use only

One set of each is included in the learning packet. The teacher should reproduce enough of the student use materials to adequately furnish his class with the proper materials.

Objectives

Included in the packet are measurable objectives. These objectives state the goals of the unit of study in such a way that both teacher and student will know what performance is expected.

Information Sheets

Each unit of instruction has information sheets which contain essential facts for that unit. These sheets are coded green and are intended for both teacher and student use. If inadequate information is contained in the student textbook, the teacher may reproduce these sheets for student use.

Instructional Materials

Instructional materials included with the unit contain transparency masters, suggested teaching activities, a lecture outline and a bibliography. These sheets are white and intended for teacher use. Each teacher is encouraged to consider these materials as a starting point and to develop additional activities and teaching materials to meet specific needs.

Student Assignment Sheets

Assignment sheets are included to give students an opportunity to apply knowledge and skill acquired through reading assignments, lecture and practice. These sheets are yellow and may be reproduced for student use.

Tests

A test is included in each unit to enable the teacher to measure student achievement. These sheets are golden and should be reproduced only for testing purposes.

Answers

Answers to student assignments and tests follow each assignment or test. These are coded pink and should be restricted to teacher use only.

TABLE OF CONTENTS

	PAGE
UNIT OBJECTIVES	1
INFORMATION	2
INSTRUCTIONAL MATERIALS (TEACHER MATERIALS) . . .	12
STUDENT STUDY/ASSIGNMENT SHEETS	22
ASSIGNMENT ANSWERS.	26
TEST (TEACHER MATERIALS)	29
TEST ANSWERS (TEACHER MATERIALS)	33

WIND POWER

ALTERNATIVE ENERGY CURRICULUM

UNIT OBJECTIVES

- To work and experiment with energy systems in order to gain an understanding of energy sources, conversion, transmission, storage and control.
- To provide an opportunity in which students can gain career information for entry into energy-related occupations.
- To develop problem-solving and creative techniques in working with energy systems.

SPECIFIC OBJECTIVES

- The student will demonstrate at an accuracy rating of 75% or above, his knowledge of 6 basic components of a wind power generation system.
- The student will demonstrate at an accuracy rating of 75% or above, his knowledge of how to obtain wind speed data.
- The student will demonstrate at an accuracy rating of 75% or above, his knowledge of how to compute 5 days storage for a home that used 1000 KWH per month.

WIND POWER

ALTERNATIVE ENERGY CURRICULUM

OUTLINE

- I. INTRODUCTION
- II. HISTORICAL DEVELOPMENT IN THE U.S.
- III. INITIAL CONSIDERATIONS
- IV. COSTS
- V. THE BASICS OF A WIND POWERED ENERGY CONVERSION SYSTEM
 - A. The Rotor and Generator
 - B. The Tower
 - C. Battery Storage
 - D. Power Converter
 - E. Back-Up System
- VI. ERDA WIND ENERGY PROGRAM
- VII. SUMMARY
- VIII. GLOSSARY

INTRODUCTION

Wouldn't it be nice to be able to unplug from the power company? Wouldn't it be a nice feeling not to have to pay a utility payment each month? The potential to do that really does exist for some people. However, there are many factors which have to be considered. It certainly is not as easy as erecting a windmill and running a plug into the house. There are many hard decisions that have to be reached. The initial expense can be very high. The site chosen for the windmill must have the necessary amount of wind needed to supply the driving force for electrical generation. To gain the proper information, a long series of wind readings over many months is necessary. A "back-up" system must be planned for those periods that occur whenever the storage capacity built into the system may not be enough to provide for the user's needs.

HISTORICAL DEVELOPMENT IN THE U.S.

Since the mid-19th century, more than 6 million small windmills have been used in the United States to pump water, generate electricity, and perform milling operations. Over 150,000 are still in operation, primarily in the western states for watering livestock in remote areas.

Types commonly used to pump water have metal fan blades 12 to 16 feet in diameter, mounted on a horizontal shaft, and have a tail-vane to keep the rotor facing the wind. A 12-foot diameter rotor of this type develops about 1/6 hp in a 15 mph wind. Small windmills used to generate electricity have two to three propeller-type blades that are connected by a shaft and gear train to a DC generator.

A large wind-powered electric system was built in the 1930's.

WIND POWER

INFORMATION

This giant machine had a 2-blade , 175 ft. diameter propeller-type rotor which weighed 16 tons and operated at a rated speed of 28 rpm to produce 1.24 mega-watts of AC power. In March 1945, one of the blades broke off near the hub, but could not be corrected because of wartime material shortages. The project was abandoned. Today there is a renewed interest in projects of this type.

INITIAL CONSIDERATIONS

Consideration must initially be about just how much wind is available at the potential users site. This information may be gathered one of two ways:

- (1) The first way to gather wind data is to use a hand held wind meter. One such instrument is made by Dwyer Instruments and costs about \$7.50. It may be ordered from Solar Wind Division of Energetech, P.O. Box 420, Norwich, VT 05055.
For useful results you should take readings exactly where you plan to place your windmill. If you plan to build a tower, you will have to take your readings from a building or tree near by. You will have to do this at least once or twice a day for a year.
- (2) The second method of obtaining the wind speed data for your location is to write the National Climatic Center, Federal Building, Asheville, NC 28801 and ask for the "Wind Tabulation Percentage Frequency of Wind Direction and Speed" for your locale. These charts cost about \$7.50. They tell what percentage of the time winds of various speeds blow, and their direction.

WIND POWER

INFORMATION

It is a rule of thumb that winds in your area should average at least 10 miles per hour if you plan on getting a useful amount of power from the wind. The average speed of the wind in Little Rock, AR is 8.7 mph. This figure is close enough to 10 mph to warrant serious consideration. However, accurate wind speed ratings for your area are necessary to make a decision.

COSTS

Anyone seriously considering wind power generation, must be aware of the immense cost of a system which could only partially fulfill your power needs. The cost of a system that would allow you to be independent of the utility company would be prohibitive. An installation capable of providing the kind of service you get from the power company is going to cost from \$15,000 to \$20,000. These high costs can be justified in a remote area where there is no available source of commercial electricity. A smaller investment in a system which would provide part of a family's needs might be feasible.

THE BASICS OF A WIND POWERED ENERGY CONVERSION SYSTEM

The following is a list of the essential components of a wind-energy generation system:

1. Rotor and Generator
2. Tower
3. Battery Storage System
4. Power Converter
5. Back-up System
6. Power Conversion Unit

Rotor and Generator

The rotor and the generator are the heart of the wind generation system. They capture the energy of the wind and convert it into useful electricity. It is important to note that the energy produced by most windmill applications is Direct Current (DC). Those that produce Alternating Current (AC) change the energy back to DC for storage in the battery storage system.

There are generally two types of rotors used on windmills:

1. Horizontal axis
2. Vertical axis

The horizontal axis type is that which is most familiar to us. They include the double blade propeller, the triple blade propeller and the multi-vane rotor. The double blade and the triple blade propellers reach the higher speeds necessary for electrical generation. The multi-vane rotor provides a larger amount torque at lower speeds. This makes it better for water pumping applications. The multi-vane usually turns too slow to be useful in generating electricity.

The vertical axis types require no wind vane to move the blades to face the wind. This type of rotor system can accept wind from any direction. There are three main types of vertical axis windmills:

1. The Savonius
2. The Darrieus
3. The Combination Savonius-Darrieus

Wind speed is very important and propeller diameter is very important. The power available from the wind is proportional to the cube power of the wind speed. Double the wind speed and you get eight

WIND POWER

INFORMATION

times as much power. The power a propeller can extract from the wind is proportional to the square of the propeller's diameter. If you double the diameter, you get four times as much power.

Tower

One of the cheapest ways to get more output from any windmill installation is to invest in a good tall tower. Anything you can do to increase the wind speed through the rotor blades will do a lot to increase the output. It has been found that even in flat areas without trees and buildings, wind speed is anywhere from 25 to 50 percent greater 30 feet above the ground. There are three types of towers that are used:

1. Guyed - this tower stands on a small one-legged base and gets its stability from the guy wires anchored to the ground.
2. Three or Four Post - this tower stands on a sturdy base and has three or four legs.
3. Tubular Steel - this tower uses a single steel tube as its method of support.

Battery Storage

The amount of storage capacity required is determined by the amount of kilowatt hours used to meet the consumer's needs. This monthly kilowatt (KWH) information is available on your monthly utility statement. Divide the monthly KWH figure by 30 to determine the average daily consumption. Should you be considering the installation of a wind power generation system where there is no prior record of electrical consumption, the only means of computation is a detailed inventory of the

WIND POWER

INFORMATION

electrical needs of the various appliances that are intended for installation in the home.

Once you have obtained the average daily KWH, convert it to amp hours (ah) by first multiplying KWH by 1000 to convert to watt hours (wh) and then using the formula $ah = wh/volts$. (ah = wh/volts means amp hours equals watt hours divided by the voltage you are choosing to use in your home.) The result will be the amp hours you use per day. A storage system capable of storing five days worth of power would have five times the amp hours of the figure computed.

Example: If we found our monthly KWH consumption to be 700 KWH, we would divide that figure by 30 to get daily consumption. The result would be 23.33 KWH, multiplied by 1000 to be 23333 watt hours. Now using the formula $ah = wh/volts$, we get $ah = 23333$ divided by 115 (most household voltage is 115). The result is 202.9 amp hours per day. Five times that figure would equal 1014 amp hours storage needed for five windless days.

A second sizing factor for storage deals with the limit to the amount of current a battery is designed to release at a given time. This rate is called the maximum discharge rate (MDR). Should your batteries have a MDR of 20 amperes, this means the most you could draw from storage would be 20 amps. Each appliance in the house will draw a specific amount of amps at 115 volts. If the total for all appliances exceed the MDR, all appliances can not be on at the same time.

Power Converter

It is necessary to convert the Direct Current (DC) that is produced by the wind generation plant and stored in the battery storage to Alternating Current (AC) for use by appliances. This means you will need a device to convert the DC from the batteries to AC. One of the

WIND POWER

INFORMATION

cheapest ways to convert DC to AC is to use a rotary converter. This is simply a DC electric motor that runs at a constant speed off battery power. It in turn drives an alternator which produces 115 volt AC.

A rotary converter should have a smooth sine wave since this is important if you want to run appliances such as a television or a stereo.

A second way to convert DC to AC is with an electronic inverter. This is an electronic device which uses transistors and electronic components to produce a sine wave. These inverters have an efficiency as high as 80 to 90 percent while a rotary unit may be only 60 percent efficient.

Back-Up System

Any system using wind power must have an alternate source of power to use if the wind does not blow for a long period of time. This back-up system may consist of a gasoline, diesel or propane powered generator, or it may be the utility company if it is available. This system would be gauged to start when the storage facilities were depleted.

ERDA WIND ENERGY PROGRAM

The U.S. Energy Research and Development Administration (ERDA) has sponsored the development of reliable and economically viable wind energy systems. Emphasis is on systems that are capable of rapid commercial expansion to produce a significant portion of the nation's future energy requirements. A number of sites, including Sandusky, Ohio and Clayton, New Mexico, have been selected for the erection of 100 kilowatt wind machines. These windmills have a propeller type rotor with a span of 125 feet and made of two 2000 pound aluminum blades. The

WIND POWER

INFORMATION

rotor begins to turn in an 8 MPH wind and it operates at its rated power level in winds of 18 MPH. A high speed gear box increases the rotor speed from 40 RPM to 1800 RPM to drive a 100 kilowatt alternator. A wind sensor, servo-motor, and gear assembly provide the directional orientation for the rotor. The entire system is mounted on top of a 100 foot open-truss tower. The 100 kilowatt power rating is enough to provide electricity to about 25 average homes.

SUMMARY

The most feasible applications for wind power has been and will continue to be those which meet the needs of the individual or small community which are remote to conventional electricity sources. Present costs (1980) appear to be about \$500 per kilowatt installed capacity for wind turbines and about \$100 per kilowatt hour for battery storage.

A plan for implementing a wind power system should include several steps.

1. The area should be surveyed for peak, average, and gustiness of winds over a span of at least a year.
2. Data on icing conditions should be considered to determine loading on rotors and tower.
3. A site must be selected which will allow access to and from for construction and maintenance.
4. The optimum size and type of support structure must be determined.
5. The precise amount of energy to be obtained from the wind must be determined.

GLOSSARY

DARRIEUS ROTOR - a vertical shaft wind rotor with flexible blades; sometimes called the rope rotor.

ELECTRONIC INVERTER - an electrical device which converts DC into AC.

ROTARY CONVERTER - a mechanically coupled electric motor and electric generator used to convert a direct current into an alternating current.

ROTOR - a rotating member.

SAVONIUS ROTOR - a vertical shaft wind rotor; sometimes called an S rotor.

WINDMILL - any of various mechanisms, such as mills, pumps, or generators, operated by the force of the wind against vanes or sails radiating about a shaft.

WIND POWER

ALTERNATIVE ENERGY CURRICULUM

INSTRUCTIONAL MATERIALS

I. DIAGRAMS

- A. Horizontal Axis Windmills
- B. Vertical Axis Windmills
- C. Storing Wind Energy

II. SUGGESTED ACTIVITIES

III. LECTURE OUTLINE

IV. BIBLIOGRAPHY

HORIZONTAL AXIS WINDMILLS

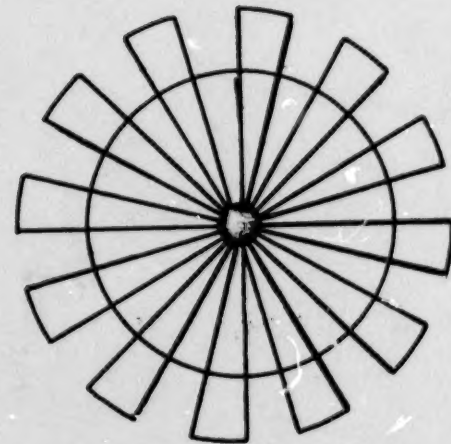
WIND POWER



TWO BLADES



THREE BLADES



MULTI-BLADED



UP-WIND



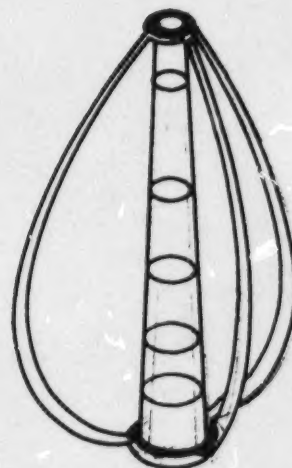
DOWN-WIND

INSTRUCTIONAL MATERIALS

VERTICAL AXIS WINDMILLS



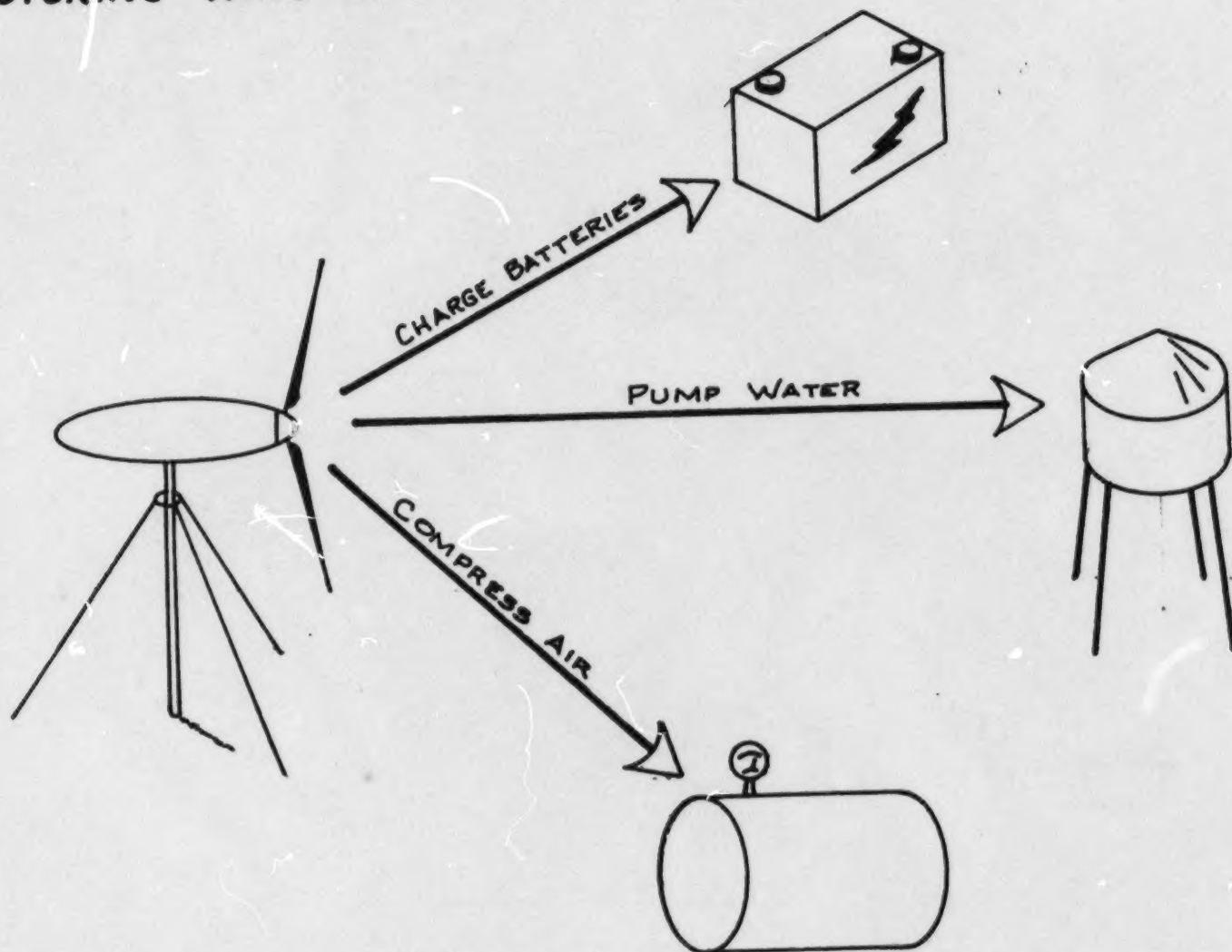
SAVONIUS



DARRIEUS

COMBINATION SAVONIUS/DARRIEUS

STORING WIND ENERGY



WIND POWER

INSTRUCTIONAL MATERIALS

SUGGESTED ACTIVITIES

- A. Have the class measure and chart the wind speed for a month. Calculate the amount of available power.
- B. Construct a model wind tunnel using an electric fan. Allow students to design and construct model wind rotors. Hold a "Blow-Off" contest to determine the most efficient design and construction.
- C. Hold a "brain storming" session to allow students to suggest alternative ways in which energy from the wind can be stored for use during the times the wind is not blowing.
- D. Assign students to calculate the ampere hours of storage capacity their family would need. Have each obtain the KWH from their utility bill, and apply the procedure described in the INFORMATION section.

WIND POWER

INSTRUCTIONAL MATERIALS

I. INTRODUCTION

1. The potential to generate their own power from the wind really does exist for some people.
2. There are many factors to be considered. The expense can be great. The site for location of the windmill must be right. The payback period of the investment must be considered.

II. HISTORICAL DEVELOPMENT IN THE U.S.

1. Over 150,000 small windmills are still in operation in the U.S. today.
2. Types used to pump water have metal fan blades 12 to 16 feet in diameter and develop 1/6 hp in a 15 mph wind.
3. In the 1930's a giant wind machine with 175 ft. propeller was constructed to generate 1.24 mega watts of electric power.

III. INITIAL CONSIDERATIONS

1. Initial consideration must be about just how much wind is available at the potential user's site.
2. Information on wind availability may be gathered by:
 - (a) on site wind meter readings.
 - (b) ordering Wind Tabulation Charts.
3. The "Rule of Thumb" for usable wind speed is 10 miles per hour.
4. The average wind speed in Little Rock, Arkansas is 8.7 mph.

IV. COSTS

1. The costs of a wind generation system capable of providing the same type of electrical supply you now have may exceed \$20,000.
2. A system to supply part of a family's needs may be more practical.

V. BASICS OF A WIND POWERED ENERGY CONVERSION SYSTEM

1. Essential components of a wind energy system are: rotor and generator, tower, battery storage system, power converter, back-up system and a power conversion unit.

A. Rotor and Generator

1. The rotor and generator capture the wind and convert it into electricity.
2. Most windmills produce Direct Current.
3. All major appliances require Alternating Current.
4. Two types of rotors used on windmills: horizontal axis and vertical axis.
5. Horizontal axis are the ones most familiar to us.
6. The double blade and the triple blade propeller types reach the higher speeds necessary for electrical generation.
7. The multi-vane type provides torque at lower speeds. It is better for water pumping applications.
8. The vertical axis types require no wind vane for facing the wind. This type of rotor can accept wind from any direction.
9. Three main types of vertical axis windmills are : the Savonius, the Darrieus, and the combination.
10. Wind speed and rotor diameter is very important.
11. Power available from the wind is proportional to the cube of the wind speed.
12. Power available from a rotor is proportional to the square of the rotor diameter.

B. Tower

1. One way to get more output from a windmill is to install it on a tower.
2. Wind speed is from 25 to 50 percent greater 30 feet above the ground.
3. A guyed tower is one type of tower . It gets its stability from guy wires anchored to the ground.
4. A three or four post tower stands on a sturdy base and needs no guy wires.
5. A tubular steel pole can be used also.

WIND POWER

INSTRUCTIONAL MATERIALS

C. Battery Storage

1. The amount of storage capacity required for those days when the wind does not blow is determined by the amount of kilowatt hours used to meet the consumer's needs.
2. The KWH information is available from the monthly utility statement.
3. A typical 5 days storage needs can be calculated using the formula given in the INFORMATION section.
4. A second sizing factor for storage is the amount of current a battery is designed to release at a given rate.
5. This Maximum Discharge Rate (MDR) will determine how much load may be on at one time.

D. Power Converter

1. Since appliances use AC, and batteries store DC, a device is needed to convert the DC to AC for use.
2. A rotary converter is a machine which converts DC to AC by mechanical motion.
3. DC can be converted to AC by electronic means also.
4. Electronic converters are 80 to 90 percent efficient while rotary converters are about 60 percent efficient.

E. Back-Up System

1. A back-up system is needed in case the storage capacity becomes depleted.
2. A back-up may be a gasoline, diesel or propane powered generator.

VI. ERDA WIND ENERGY PROGRAM

1. The U.S. government is sponsoring the development of large commercial wind energy systems.
2. A number of sites have been selected for the location of wind generators.
3. These large machines will provide enough electricity for about 25 homes.

VII. SUMMARY

1. The best applications are those for areas remote to conventional electricity sources.
2. Present costs are about \$500 per kilowatt generating capacity and \$100 per kilowatt hour storage capacity.
3. Plans for installing wind power should consider:
 - a. peak, average and gustiness of the winds
 - b. icing conditions
 - c. access for construction and maintenance
 - d. size and type of the support structure
 - e. the amount of energy needed

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WIND POWER

STUDENT STUDY SHEET

1. Does the potential for wind energy generation really exist?
2. What is the initial consideration for deciding if you should install a wind generation plant?
3. What are the two ways to obtain wind data?
4. What is the average wind speed in Little Rock, Arkansas?
5. What is the "Rule of Thumb" for the average speed necessary for getting a useful amount of power from a windmill?
6. Know about the cost of a wind power generation system.
7. What are the essential components of a wind powered generation system?
8. What type of current is usually produced by a windmill?
9. Name the types of rotors available for windmills.
10. Which type is best for electric power generation?
11. How does wind speed affect the amount of power available from the wind?
12. How does propeller diameter affect the amount of power available from a windmill?
13. What are the three types of towers?
14. How do you compute a 5-day storage capacity?
15. What does Maximum Discharge Rate mean?
16. What determines the MDR?
17. What are the steps to be included in a plan for implementing a wind power system?

WIND POWER

STUDENT ASSIGNMENT SHEET

ASSIGNMENT NO. 1

1. Name and define the 5 basic components of a wind power generation system.

WIND POWER

STUDENT ASSIGNMENT SHEET

ASSIGNMENT NO. 2

1. Name two ways of obtaining wind speed data.

2. What is the minimum period the data should cover?

WIND POWER

STUDENT ASSIGNMENT SHEET

ASSIGNMENT NO. 3

1. Demonstrate how you would compute 5 days storage for a home that used 1000 KWH of electricity per month.

WIND POWER

ASSIGNMENT ANSWERS

ASSIGNMENT NO. 1

1. Name and define the 5 basic components of a wind power generation system.

The following is a list of the essential components of a wind power generation system:

- A. Generator and rotor
- B. Tower
- C. Battery Storage System
- D. Power Converter
- E. Back-up System

Defined:

- A. Generator and rotor - the heart of the wind power generation system. They capture the energy of the wind and convert it to useful electricity.
- B. Tower - necessary to raise the rotor and generator up to a level where the wind blows harder. This is usually a minimum of 30 feet.
- C. Battery Storage System - a battery storage system is necessary for those periods of time when the wind is not blowing and the windmill is not generating.
- D. Power converter - this unit is used after the electricity is taken out of battery storage for use by the household appliances. This unit converts direct current into alternating current.
- E. Back-up System - the back-up system may consist of a gasoline, diesel or propane generator. This system would be started when the storage system was depleted.

WIND POWER

ASSIGNMENT ANSWERS

ASSIGNMENT NO. 2

1. Name two ways of obtaining wind speed data.

- A. A hand held wind meter observation at the location and the height you plan to place your windmill.
- B. Write the National Climatic Center, Federal Building Asheville, North Carolina, 28801 and ask for the "Wind Tabulation, Percentage Frequency of Wind Direction and Speed" for your area.

2. What is the minimum period the data should cover?

The area should be surveyed for peak, average, and gustiness of winds over a span of at least a year.

WIND POWER

ASSIGNMENT ANSWERS

ASSIGNMENT NO. 3.

1. Demonstrate how you would compute 5 days storage for a home that used 1000 KWH of electricity per month.
-

- A. Divide 1000 KWH by 30 days. This equals a daily average power use of 33.333 KWH.
- B. Multiply 33.333 KWH by 1000 to convert to 33,333 watt hours.
- C. Use the formula $ah = wh / volts$. wh is 33,333 watt hours. Volts is 115 volts since this is the common house voltage. The result is 289.85 ampere hours (ah) per day.
- D. Multiply the ah needed each day (289.85) by the number of days storage needed (5). The result of 1449.25 ampere hours is the amount of storage needed for a 5-day supply for a home that used 1000 KWH per month.

WIND POWER

TEST

NAME _____

MULTIPLE CHOICE (choose the best answer) DATE _____

GRADE _____

- _____ 1. Initial consideration for windmill installation must be:
- A. Cost
 - B. Time of installation
 - C. Wind availability
 - D. Placement of the tower
- _____ 2. One of the ways to gather wind data mentioned in the text was to:
- A. Wet your finger and hold it over your head
 - B. Call the weather bureau
 - C. Look in an encyclopedia
 - D. Take wind readings for a year on the site
- _____ 3. The average wind speed in Little Rock, Arkansas is:
- A. 7.8 mph
 - B. 8.7 mph
 - C. 10 mph
 - D. None of the above
- _____ 4. The "rule of thumb" about the minimum wind speed for useful electrical generation is _____ mph.
- A. 7.8 mph
 - B. 8.7 mph
 - C. 10 mph
 - D. None of the above
- _____ 5. Wind generation is:
- A. Very costly
 - B. Not very costly
 - C. Very cheap
 - D. Free
- _____ 6. To get the same type of electrical service from wind power generation that you get from the utility system, you may have to spend:
- A. \$350.00
 - B. \$ 3,500.00
 - C. \$10,000.00
 - D. \$15,000.00

WIND POWER

TEST

- ____ 7. The ____ and the ____ are the heart of the wind generation system.
- A. Storage and the Utility company
 - B. Tower and the base
 - C. Rotor and the generator
 - D. Savonius and the Darrieus
- ____ 8. Most windmill generators produce:
- A. Alternating Current
 - B. Direct Current
 - C. Transverse Current
 - D. Reverse Current
- ____ 9. One of the cheapest ways to get more output from a windmill is to:
- A. Invest in large generators
 - B. Invest in the utility company
 - C. Invest in plastic rotors
 - D. Invest in a good tall tower
- ____ 10. It has been found that wind speed is ____ to ____ percent greater 30 feet above the ground.
- A. 10 to 30
 - B. 25 to 50
 - C. 40 to 80
 - D. 70 to 100
- ____ 11. To compute storage capacity required, divide the monthly kilowatt hours listed on the utility statement by ____.
- A. 30
 - B. 50
 - C. 100
 - D. 1000
- ____ 12. Which is the correct formula for calculating amp hours?
- A. $wt = \text{volts} / ah$
 - B. $IQ = MA / CA$
 - C. $ah = wh / \text{volts}$
 - D. $wh = MC^2$
- ____ 13. The most current that can be taken from a battery at one time is called:
- A. Direct Discharge Current
 - B. Maximum Penalty Allowed
 - C. Maximum Discharge Rate
 - D. Indirect Tax Rate

WIND POWER

TEST

- ____ 14. Most household appliances use ____ current.
- A. Direct
 - B. Alternating
 - C. Indirect
 - D. Pulsating
- ____ 15. One of the ways to convert Direct Current to Alternating Current is to use:
- A. A pair of chop sticks
 - B. An electric egg beater
 - C. A rotary converter
 - D. A rotary table
- ____ 16. It is important that the converter have a ____ for static free appliance usage.
- A. Smooth sine wave
 - B. Smooth line
 - C. Line drive
 - D. Drive train
- ____ 17. While a rotary converter may be 60 percent efficient, an electronic inverter may be ____ percent efficient.
- A. 25 to 50
 - B. 39 to 82
 - C. 80 to 90
 - D. 90 to 110
- ____ 18. The power available from the wind is proportional to the ____ of the wind speed.
- A. Square
 - B. Cube
 - C. Weight
 - D. Time of day
- ____ 19. Double the diameter of the rotor and the power available increases:
- A. Twice
 - B. Three times
 - C. Four times
 - D. Ten times
- ____ 20. Large windmills have been built to supply power to as many as ____ homes.
- A. 25
 - B. 250
 - C. 2500
 - D. 25,000

WIND POWER

TEST

LISTING

21. List two (2) considerations when deciding to install wind energy generation equipment.

A. _____

B. _____

22. List five (5) components of a wind energy generation system.

A. _____

B. _____

C. _____

D. _____

E. _____

23. List three types of towers used to support windmills.

A. _____

B. _____

C. _____

24. List two types of rotors.

A. _____

B. _____

WIND POWER

TEST ANSWERS

MULTIPLE CHOICE

- | | | | |
|------|-------|-------|-------|
| 1. C | 6. D | 11. A | 16. A |
| 2. D | 7. C | 12. C | 17. C |
| 3. B | 8. B | 13. C | 18. B |
| 4. C | 9. D | 14. B | 19. C |
| 5. A | 10. B | 15. C | 20. A |

LISTING

21. A. Wind availability
B. Cost
22. A. Generator and Rotor
B. Tower
C. Battery Storage System
D. Power Converter
E. Back-up System
23. A. Guyed
B. Three or Four Post
C. Tubular Steel Pole
24. A. Horizontal Axis
B. Vertical Axis

Dear Teacher:

The evaluation of the completed materials is a critical step in the curriculum development process. It is required that all recipients of the materials prepared by the Alternative Energy Curriculum Project furnish such an evaluation. After you have had time to review this learning packet, complete this questionnaire and return it to the Arkansas Research Coordinating Unit.

This evaluation is for: (Check (✓) one)

() Alcohol Fuels

() Nuclear Energy

() Wind Power

() Conservation

() Solar Energy

Evaluate each section of the learning packet by placing a check (✓) in the Favorable or Unfavorable column. If the evaluation is Unfavorable, please state the reason in the space beside the section name.

Favorable Unfavorable

()	()	Information Section	_____
()	()	Instructional Materials	_____
()	()	Student Study/Assignment Sheets	_____
()	()	Tests	_____

Evaluate the following characteristics of the learning packets by placing a check (✓) in the appropriate response.

Readability: () Too High () Too Low () Right Grade Level
Material Length: () Too Long () Too Short () Correct Length
Technical Level: () Too Technical () Too General () Right Technical Level

Do you plan to use this material in your classes? Check (✓) Will or Will Not. If Will, supply requested information. If Will Not, state reasons.

() Will Name of Class _____
Grade Level of Class _____
School Name _____

() Will Not Reasons _____

If additional Alternative Energy Curriculum materials would be of use in your classes, check (✓) those energy topics which should be developed.

() Bio-Mass () Fuel Cells () Methane () Coal () Geothermal
() Other _____

Thank you for your evaluation. Fold this questionnaire so the return address is on the outside. Seal with a small piece of tape. Place a first class stamp in the upper right hand corner and mail.

CE 029148

IMPORTANT !!!
EVALUATION QUESTIONNAIRE

Place
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